Preliminary Soil Mineralogy Studies on Krasnozems in the Innisfail District of North Queensland, Australia

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ABSTRACT: A preliminary investigation of four soil series of the Pin Gin family of krasnozem soils has confirmed the results of field observation on their history and has pointed to the diverse nature of their origins and weathering processes. The weathering pattern and origin can account for differences in their fertility in the virgin state.

STUDIES OF THE MINERALOGY of soils can lead to a better understanding of the origin and history of soils and to predicting their physical and chemical behaviour as a medium for the growth of plants. Sherman (1955:110) has discussed this aspect in relation to krasnozems in Hawaii. With this in mind the author, in 1962, commenced an investigation of soils in the sugar cane growing area of Goondi near Innisfail, Queensland. Soils were classified and mapped, and samples were taken from modal profiles for further study.

This paper describes the investigations carried out on the Pin Gin family of soils which are classified as krasnozems (Stevens, 1953: 24–26), latosols (Cline, 1955:70), or oxisols (soil survey staff, U.S.D.A. 1960:238–247). Other workers have examined the mineralogy of North Queensland soils. Leverington (1955: 9) reported on several alluvial samples near the Goondi area. Simonett (1961) and Simonett and Bauleke (1963) related rainfall to the weathering mean in a detailed study of several krasnozem profiles in the Cairns-Atherton region. Robinson (1964) has studied samples collected by Teakle (1950) on the Atherton Tableland. He established that there was a relationship between mean annual rainfall and the presence of gibbsite. The work both of Simonett and of Robinson confirmed that of Tanada (1951) in Hawaii, who showed a similar relationship of weathering stage to mean annual rainfall.

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SOIL DESCRIPTIONS

The soils are developed in an area of approximately 140 inches rainfall per annum. There is a distinct dry season from May to December.

The Pin Gin family has been classified into four soil series on the basis of texture as determined in the field, the occurrence of gravels, and the presence of euhedral quartz. Tentative conclusions on the origin of these soils were drawn from field observations.

Pin Gin Series (Darveniza Farm)

0–7 inches. Yellow-red (dry) 5YR 4/6, dusky-red (moist) 1OR ¾ loam. Moderate fine granular structure. Friable when moist, slightly hard when dry.

7–48+ inches. Yellow-red (dry) 5YR 4/6, dusky-red (moist) 1OR ¾ loam. Gradually developing to fragmental structure which is friable when moist. Infrequent fine clear quartz at depth with occasional gravel.

This soil generally grades into weathered olivine basalt at lower depths. The basalt originates from several vents on the eastern and western edges of the Johnstone River Valley which were formed in recent times, after the main tableland eruptions.

Eubenangee Series (O'Connor Farm)

0–8 inches. Yellow-red (dry) 5YR 4/6, dark red-brown (moist) 2.5YR ¾ loam. Weak fine subangular blocky structure with friable to firm consistence. Infrequent gravel.

8–33 inches. Dusky-red (moist) 1OR 3/3 loam. Weak fine granular structure with firm to friable consistence, gravel common.

33–36 inches. As above with gravelly "stone" line consisting of "cuirasse."

36 inches. Similar to 8–33 inch layer.

The soil contains an amount of clear euhedral quartz with some stone lines of basaltic and nonbasaltic origin, and occurs generally over steep hills. Field observations, therefore, seemed to indicate that the soil was of mixed origin, containing colluvial materials derived from basaltic and nonbasaltic sources.

Daradgee Series (McAvoy Farm)

0–8 inches. Yellow-red (dry) 5YR 4/8, dark red-brown (moist) 2.5YR 3/4 clay loam. Moderate fine granular structure. Friable consistence when moist.

8–44+ inches. Dusky-red (moist) 10R 3/4 grading to dark red (moist) 10R 3/6 clay loam. Fragmental, firm consistence when moist.

This soil appears at elevations of approximately 50–80 ft above sea level and is associated with upper-level river terraces. In some areas it occurs as a band of uniform width between the river terraces and Pin Gin or Eubenangee soils. These field observations seemed to indicate that the soil had an alluvial origin.

Mundoo Series (Grima Farm)

0–8 inches. Yellow-red (dry) 5YR 4/6, dark red-brown (moist) 2.5YR 3/4 loam. Apedal, friable with some gravel plentiful, fine, euhedral, clear quartz.

8–30 inches. Dark red (moist) 10R 3/6, gravelly loam. Fragmental, firm consistence when moist, some gravel and plentiful fine, euhedral clear quartz.

30–42 inches. Similar to 8–30 inch layer, but plentiful gravel.

42+ inches. Similar to 8–30 inch layer.

The main features of the Mundoo series are the abundance of clear quartz throughout the profile and the occurrence of scattered, discontinuous "cuirasse" layers. The soil forms a gently sloping dissected plain and can be traced under the olivine basalt flow. It could be hypothesised from field observations that this soil was of nonbasaltic origin which had undergone a laterization process, had been covered by a basalt flow, and later was exposed.

Crook and McGarity (1955) have described the presence of considerable quantities of clear, high-temperature, euhedral quartz in some krasnozem soils of the Lismore area. They concluded that the quartz was derived from rhyolitic tuffs. In the case of the Mundoo soil, quartz could be derived from quartz rhyolite of the Upper Paleozoic Glen Gordon volcanics. However, as the nearest outcrop is 26 miles to the southwest, it is difficult to attribute the origin of quartz to this source, even though there is no other satisfactory explanation.

LABORATORY METHODS

Soil samples from pit profiles were air dried and passed through a 2-mm sieve. Air drying was used because field moisture contents were in the order of 25–40% by weight and indicated that allophane was not present.

After treatment with H_2O_2, "free" iron was extracted, using the dithionite method (Jackson, 1956:57). The clay ($< 2\mu$) fraction was separated by centrifugation and the silt and sand fractions by sieving. X-ray diffraction patterns were obtained on oriented clay samples which were washed to remove excess salts. The heavy and light mineral fractions were separated by flotation in bromoform, using the silt size samples. These fractions were dried and weighed separately, then mounted in Canada balsam for microscopic investigations. The percentage of tourmaline and zircon was estimated by counting mineral grains in the heavy fraction. Differential thermal analysis was carried out on air-dried samples ground to pass through a 70-mesh sieve, using 0.4-gm samples with a heating rate of approximately 10 C per minute. Samples were treated with hot 0.5N sodium hydroxide and were analysed again on the DTA apparatus to distinguish the goethite from the gibbsite peak.

RESULTS AND DISCUSSION

The table shows marked differences in mineralogical properties among the four soil series.

Light/Heavy Mineral Ratio

Because most of the light fraction is quartz and the heavy fraction is magnetite the light/

TABLE 1

SOIL MINERALOGY DATA ON THE PIN GIN FAMILY OF KRASNOZEMS

SOIL AND LOCATION	DEPTH INCHES	% FREE IRON	SILT FRACTION			X-RAY DATA			DTA DATA		
			L/H* RATIO	% TOURMALINE	% ZIRCON	KAOLIN	GIBBSITE	HEMATITE	KAOLIN	GIBBSITE	GOETHITE
Pin Gin loam	0-2	11.2	.47								
(Jones farm)	4-6	10.6									
	9-11	11.0	.29	nil	nil	M.S.†	M.S.	M.W.	M.S.	M.S.	M
	16-18	11.2									
	22-24	11.5	.35	nil	nil	M.S.	M.S.	M.W.	M.S.	M.S.	M
Eubenangee	1-3	18.5	2.3	.5	1.1	M	S	S	M	S	M
clay loam	4-6	16.9									
(Blundell	9-11	16.8									
farm)	12-14	16.9	.9	.3	1.0	M	S	S	M	S	M
	15-17	16.5									
Daradgee	3-5	7.7	14.2	1.5	1.5	M.S.	M	M.W.	S	M	M.W.
clay loam	7-9	7.7	—	—	—						
(McAvoy	11-13	7.6	13.3	2.1	1.1						
farm)	13-15	8.1	13.0	3.7	2.3	M.S.	M	M.W.	S	M	M.W.
	20-22	8.3	5.3	3.4	4.1						
Mundoo	0-7	6.8	19.2	3.9	7.9	V.W.	V.S.	M.W.	V.W.	V.S.	M.W.
clay loam	7-13	7.8	11.7	—	—						
(Fomiatti	13-19	5.1	13.1	1.8	4.2	V.W.	V.S.	M.W.	V.W.	V.S.	M.W.
farm)	19-25	4.2	26.7	2.2	17.2						

* L/H refers to the ratio of the light to the heavy fraction in the silt fraction.
† Intensity of peaks indicated as follows: V.S., very strong; S, strong; M, medium; M.W., medium weak; W, weak.

heavy mineral ratio is often a guide to the origin of the soil material. A low ratio reflects a basic rock origin, and a high ratio an acidic rock origin (Carroll, 1949:23). However, it could indicate a certain weathering stage (Jackson and Sherman, 1953:239), since a low ratio may represent a highly weathered soil of either basic or acidic rock origin.

Zircon and Tourmaline

The presence of zircon and tourmaline shows that some of the soil material is of acid and intermediate igneous rock origin (Milner, 1940: 355). These minerals can survive several erosion cycles and are accompanied in these soils by minerals (magnetite, quartz) which can also survive several cycles. It is most likely, therefore, that the Daradgee and Mundoo soils are derived from reworked sediments. The Eubenangee soils show some evidence of this, but the Pin Gin soils do not.

X-Ray and D.T.A. Data

These data show differences in kaolin and gibbsite content from the gibbsite-dominant Mundoo soil to the kaolin-dominant Daradgee soil. According to Jackson and Sherman (1953: 239), the classification of these soils into their order of weathering based on kaolin, gibbsite, and goethite content would be: Mundoo soils (most weathered), Eubenangee soils, Pin Gin soils, Daradgee soils (least weathered).

"Free" Iron

The free iron content shows the Eubenangee soil to be highly weathered and, because of the relatively low figures for a well weathered soil, appears to confirm the impression that the Mundoo soil is not of basic rock origin.

Field Observation and Mineralogy Studies

The field observations (given under soil descriptions) are largely confirmed by the mineralogy studies.

The Pin Gin soil is derived primarily from the basaltic material in the lower profile, and, while it is of recent origin, has weathered rapidly to produce some gibbsite and goethite. The parent material of the Eubenangee soil is largely basalt. However, the presence of zircon and tourmaline shows that some material is of acid rock origin. Therefore, it is colluvial material from mixed sources which (according to the gibbsite, goethite and free iron content) has been highly weathered or has derived from highly weathered sources. The Daradgee soil shows ample evidence that the material has been reworked and is partly of nonbasaltic origin. The weathering stage is not advanced. Similarly, the Mundoo soil consists of reworked sediments (shown by the high tourmaline and zircon contents), but, inasmuch as it contains a large proportion of gibbsite, it is highly weathered. From the presence of this soil beneath post-Tertiary flows and the occurrence of a general laterisation period in the Pliocene (Connah and Hubble, 1960), it is assumed that most of the weathering process took place in the Pliocene. The soil remained buried by basalt flows until recent times.

It is of interest, then, that these four soil series, classed generally as krasnozems or lateritic krasnozems, have different origins and have undergone different weathering processes.

Fertility Status and Weathering

Much has been written about the correlation of soil classes with fertility status and crop or pasture production (Butler, 1964). The general conclusion appears to be that there is little correlation between series and that the variation from series to series is as high as that within the series. This is especially so in sugar cane growing regions which have been growing cane for up to 50 years (Monteith, 1949). In this case, however, the soil type can be related to production in the initial establishment period. The Mundoo soil was abandoned for cane growing at one stage and has been brought back into production only by the use of factory filter waste, molasses, and great amounts of fertilizer. The soil has been the most infertile of the four in the Pin Gin family. The establishment of cane growing was difficult on the Eubenangee soils also, but growth responded well to factory filter waste and superphosphate. The Pin Gin and Daradgee soils have not proved to be difficult soils for cane growing. The order of fertility in the early period of cane growing is, in this case, similar to the order of weathering. Therefore, a mineralogical appraisal of virgin soils should be a guide to production performance.

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